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# The Effect of F-8 Aircraft Maneuvers on Atoll (AA-2) Performance

[Unclassified Title]

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*Radar Division*

September 1970

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NAVAL RESEARCH LABORATORY
Washington, D.C.

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SECRET

MEMORANDUM

SUBJECT: The Effect of F-8 Aircraft Maneuvers on ATOLL (AA-2) Performance.

Background

(S) This report is the second of a series which describe the effectiveness of maneuvers as a countermeasure against the ATOLL. The ATOLL is the most often observed air-to-air missile in communist controlled countries such as North Vietnam. It is an accurate copy of the early Sidewinder, and data which permit its accurate simulation are readily available.

Findings

(S) The optimum maneuver as a countermeasure for the F-8 aircraft is a high-g turn toward the missile, but even this maneuver does not insure the missile will miss. Specifically, there exist situations in which a maneuver initiated before the missile is launched, will not guarantee the missile will miss. One such condition occurs when an ATOLL is launched at short range from a position directly on the tail of the F-8.

R & D Implications

(S) Since maneuver alone is not fully effective, alternative countermeasures must be considered. The effectiveness of IR suppression, flares, and other active countermeasures should be examined. However, it should be noted that no countermeasure will be fully effective unless a threat detection system is developed to alert the pilot of the threat and/or to operate a reflexive type countermeasure system.

Recommended Action

(S) Countermeasures cannot be fully successful until a threat detection system is developed which will operate effectively in the lethal zone of the ATOLL. This study points out the need for an alerting device to protect the rear hemisphere of our fighter and attack aircraft. A missile launch detector and/or tail-warning radar system is needed and should be developed to reduce the effectiveness of the ATOLL and similar missiles.

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Tactical Analysis Section
Airborne Radar Branch

## ABSTRACT (S)

An analysis was made to determine the capability of the F-8 aircraft to evade the ATOLL missile by maneuver. Realistic computer simulations of both the ATOLL and the F-8 were combined with the IR characteristics of the F-8 and the atmosphere to provide the tool for analysis. The simulation results define maneuver requirements for the F-8 in the air combat maneuvering environment. It is concluded that maneuver alone is not always a sufficient countermeasure.


## PROBLEM STATUS (C)

This is a final report on the effectiveness of maneuvers by an F-8 aircraft as a countermeasure against ATOLL. Work on other countermeasures and other aircraft is continuing.

## AUTHORIZATION

53D01-03
A-05-533647/652-1/S3190000

# TABLE OF CONTENTS

# THE EFFECT OF F-8 AIRCRAFT MANEUVERS ON ATOLL (AA-2) PERFORMANCE (Unclassified Title)

## I. INTRODUCTION

(S) By Ref. (1), the Naval Air Systems Command, AIR-533365C, requested the Naval Research Laboratory (NRL) to investigate the capability of various U.S. aircraft to counter the ATOLL missile. As one part of the overall investigation, Ref. (1) tasks NRL to study how U.S. aircraft can defeat the ATOLL by maneuvering. The importance of this problem stems from the fact that Russian-built MIG aircraft armed with the ATOLL missile, have engaged U.S. aircraft in Vietnam. Reference (2), which describes the effectiveness of maneuvers by the F-4B aircraft as a countermeasure against the ATOLL, is the first report of a series resulting from this study. This second report in the series describes the effectiveness of maneuvers by the F-8 aircraft. It will be followed by reports which describe the use of IR flares as currently mechanized on the F-4 and F-8 aircraft, the use of several IR suppression techniques on the F-4, and the use of certain active IR countermeasure devices on the F-4 and/or the A-4.

## II. COMPUTER REPRESENTATION

### A. General Description

(C) A four degree of freedom computer model of the F-8 aircraft and a six degree of freedom computer model of the ATOLL have been constructed for this study. The thrust, drag, and lift characteristics of the F-8 are included to assure realistic simulation of maneuvers. Measured F-8 IR data, atmospheric attenuation formulas, and ATOLL detector sensitivity measurements were used to develop an IR signal model. ATOLL tracking error data were combined with a Sidewinder IA tracking model for the electronics' characteristics. Sidewinder IA gas servo performance data are included in the guidance and autopilot model. Tables of aerodynamic moments along with normal and axial forces for the Sidewinder IA are used in the computer program to calculate missile response. The time and position at which ATOLL fuzing and warhead detonation occur are calculated with respect to the F-8 tailpipe. A full description of the missile model is found in Ref. (2) and will not be repeated in this report except where differences are noted.

B. Characteristics of the F-8 Aircraft

(U) The characteristics of the F-8 aircraft as used in this study are given in Tables 1-4. The maximum lift characteristic of the F-8 as a function of Mach number is shown in Table 1. These data are used to limit the computed maneuver of the F-8 so that maneuvers beyond its aerodynamic capability, as a function of speed and altitude, are not used in the study. The military thrust of the F-8 as a function of Mach number and altitude is given in Table 2. Table 3 lists the total drag coefficient of the F-8 as a function of Mach number and lift coefficient. IR radiancy is found in Table 4 and is based on data taken at the Naval Weapons Center (NWC), China Lake, and shown on Fig. 1.

## III. ATOLL PERFORMANCE

### A. Non-Maneuvering Target

(S) The lethal zones for the ATOLL when fired against a non-maneuvering F-8 aircraft are not included in this report because they are very much like those for the F-4B as reported in Ref. (2). These zones for the two aircraft are very similar since there is negligible aerodynamic difference between two aircraft flying a straight line at a constant speed. The lethal firing zones are different only because of differences in IR radiancy of the two aircraft. Although the F-4B has two engines while the F-8 has only one, the NWC measurements shown in Fig. 1, indicate that IR radiancy of the F-8 is equal to or slightly greater than that of the F-4B. Thus the effective attack zone against the F-8 will be somewhat expanded over the corresponding zone for the F-4B.

### B. Tactical Situation

(S) The earlier study for the F-4B aircraft, Ref. (2), demonstrated that the ATOLL has successful launch zones for every situation examined. In that study, it was hoped that a maneuver initiated when the ATOLL was launched would be a fully effective countermeasure. Since that hope was not realized, this study considers launches of the ATOLL while the target is maneuvering. Thus this effort is not intended to compare the relative effectiveness of F-8 and F-4B maneuvers. Rather, it intends to determine what must be done to defeat the ATOLL missile in the air combat maneuvering (ACM) environment.

(C) In this study, it is assumed that the missile is launched after the F-8 fully developed its final maneuver. Since Ref. (2) demonstrated that the hard turn was the most effective maneuver against the ATOLL, only that maneuver is considered in this study. It is assumed that the ATOLL is launched after the F-8 has attained the bank angle required for a coordinated turn and that the full g load has developed on the aircraft. This will occur one second after the initiation of the turn. This is a situation characteristic of the ACM environment in which the aircraft are being continuously and violently maneuvered.

(U) When the target is not maneuvering, it is reasonable to assume that an attacker using the element of surprise can achieve almost any launch point he desires. However, he may not be able to do so when his presence is known. Thus, the existence of a zone for the successful launch of an ATOLL against a maneuvering F-8 does not necessarily indicate that the maneuver is ineffective. It may be that the maneuver will prevent the attacker from reaching the successful launch zone. An analysis of whether these successful ATOLL launch zones can be attained by an attacker in the ACM case is beyond the scope of this study.

C. Launch Aspect Angle Effects

(S) Figures 2-19 contain the results of the simulation. Aspect angle stands out as the one parameter having critical importance. The result for two aspect angles, 180° (tail-on) and 160° (20° off tail), are given on each figure. Moderate to total degradation of ATOLL intercept capability is indicated at 20° off the tail for each case. ATOLL performance varies from "no capability" regardless of target maneuver, as shown in Fig. 6(b), to "effective for any target maneuver" as shown in Fig. 2(a), but there is a maneuver which is effective in nearly every case at 20° off the tail. One execption is the case of maximum range at 30,000 feet altitude.

(S) In all "tail-on" cases except that shown on Fig. 10, the 4-g turn is not enough to produce a safe miss (25 ft.). It should be noted that a launch range of 7000 feet shown on Fig. 10 is beyond the normal maximum range of the ATOLL. In 12 of the 18 "Tail-on" cases studied, no maneuver within the capability of the F-8 aircraft would produce a safe miss. However, in all cases except the one shown in Fig. 19(b), a 5-g turn was adequate to produce a safe miss at 20° off the tail. It should be noted that in five out of the seven minimum range cases, 20° off the tail was outside of the ATOLL launch envelope for non-maneuvering F-8.

(C) The reason for the poor performance of the ATOLL at angles off the tail is the seeker lock-up technique employed. The pilot is required to point the missile directly at the target and launch. This requires the missile to maneuver merely to develop the proper lead angle for intercept. This missile maneuver requirement generally places the ATOLL's launch zone directly on the tail.

D. Launch Range Effects

(S) The effectiveness of maneuvers at minimum ATOLL range is higher in this study than in the previous F-4B aircraft study. Here, in the seven minimum range, tail-on cases, maneuver produced a 10 feet miss in four cases as opposed to only one case in the F-4B study. Since aircraft maneuver levels used in this study are no higher than those for the previous study, the explanation for this difference lies in the fact that the F-8 is assumed to be maneuvering when the ATOLL is launched whereas the F-4B was assumed to initiate maneuver at missile launch. Thus the F-8, in this study, has been given about a one second advantage over that given the F-4B. This is a significant difference since the total missile flight time at minimum range, is approximately 3 seconds.

(S) Maneuver effectiveness increases as the missile launch range increases. For example, at the minimum range of (3000 ft) as shown on Fig. 6(a), a 7-g maneuver produces a 7.5 feet miss whereas a 7-g turn at a launch range of 5000 feet produced a miss in excess of 50 feet (see Fig. 7(a)). The same trend can be seen on Figs. 11, 12 and Figs. 14, 15 each of which assume different tactical conditions.

## IV. CONCLUSIONS

(S) 1. There exist successful launch zones for ATOLL regardless of maneuvers by the F-8 aircraft. These are at minimum range and in a "tail-on" position.

(S) 2. Even though the effectiveness of the ATOLL in the ACM environment is decreased from that of a maneuver-after-launch situation, the effectiveness of maneuver alone is not sufficient to guarantee protection of the aircraft under all conditions.

## V. RECOMMENDATIONS

(S) 1. Pilots should be trained in ATOLL performance, with emphasis on those situations in which maneuver is an effective countermeasure and those in which it is not an effective countermeasure.

(S) 2. Studies should be made to determine the probability of enemy aircraft being able to reach a successful ATOLL launch point in the air combat maneuvering evnironment.

(S) 3. Studies of the effectiveness of IR flares and other active countermeasures should be pursued.

(S) 4. Further studies should be conducted to determine the effect of afterburner power on aircraft vulnerability to ATOLL.

(S) 5. Special tailpipe shielding should be investigated to reduce IR signature in the upper hemisphere of U.S. aircraft.

(S) 6. The Navy should pursue the investigation of countermeasure techniques which have potential effectiveness against a missile launched directly tail-on at minimum range.

## VI. REFERENCES (U)

(1) AIRTASK No. A05533647/6521/53190000 "Infrared Threat Analysis"

(2) H. Toothman, C. Loughmiller, and R. Lister, "The Effect of F-4B Maneuvers on ATOLL (AA-2) Performance," NRL MR 1989, Secret-Noforn, 1969

## ACKNOWLEDGEMENTS (U)

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NAVAL RESEARCH LABORATORY

Jacqueline Imes and Richard Lister for developing the figures

| MACH | $C_{LMAX}$ |
|---|---|
| 0.50 | 0.930 |
| 0.62 | 0.900 |
| 0.75 | 0.880 |
| 0.80 | 0.880 |
| 0.85 | 0.890 |
| 0.90 | 0.925 |
| 0.94 | 0.950 |
| 1.00 | 1.100 |
| 1.05 | 1.300 |
| 1.10 | 1.100 |
| 1.15 | 0.975 |
| 1.20 | 0.925 |
| 1.30 | 0.810 |
| 1.40 | 0.740 |
| 1.50 | 0.690 |

Reference area = 375 $FT^2$

$C_{LMAX}$ = Max tactically usable lift coefficient

TABLE 1 - F-8 MAXIMUM LIFT COEFFICIENT (U)

| ALTITUDE | MACH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 | 1.0 |
| 0 | 10,900 | 11,100 | 11,300 | 11,300 | 11,300 | 11,300 | 10,700 | 9,216 | 7,733 |
| 5,000 | 9,666 | 9,858 | 10,050 | 10,107 | 10,164 | 10,221 | 9,883 | 8,938 | 7,994 |
| 10,000 | 8,433 | 8,616 | 8,800 | 8,914 | 9,028 | 9,142 | 9,066 | 8,661 | 8,255 |
| 15,000 | 7,200 | 7,375 | 7,550 | 7,721 | 7,892 | 8,064 | 8,250 | 8,383 | 8,516 |
| 20,000 | 6,225 | 6,362 | 6,500 | 6,685 | 6,871 | 7,057 | 7,275 | 7,491 | 7,708 |
| 25,000 | 5,250 | 5,350 | 5,450 | 5,650 | 5,850 | 6,050 | 6,300 | 6,600 | 6,900 |
| 30,000 | 4,300 | 4,475 | 4,650 | 4,828 | 5,007 | 5,185 | 5,425 | 5,775 | 6,125 |
| 35,000 | 3,350 | 3,600 | 3,850 | 4,007 | 4,164 | 4,321 | 4,550 | 4,950 | 5,350 |
| 40,000 | 2,775 | 3,000 | 3,225 | 3,367 | 3,510 | 3,653 | 3,850 | 4,166 | 4,483 |
| 45,000 | | | | 2,728 | 2,857 | 2,985 | 3,150 | 3,383 | 3,616 |
| 50,000 | | | | 2,175 | 2,275 | 2,375 | 2,500 | 2,675 | 2,850 |
| 55,000 | | | | 1,621 | 1,692 | 1,764 | 1,850 | 1,966 | 2,083 |
| 60,000 | | | | 1,300 | 1,350 | 1,400 | 1,475 | 1,558 | 1,641 |
| 65,000 | | | | 978 | 1,007 | 1,035 | 1,100 | 1,150 | 1,200 |

TABLE 2 – F-8 INSTALLED MILITARY THRUST (LBS) (U)

**MACH 0.5**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0175 |
| 0.020 | 0.0209 |
| 0.040 | 0.0247 |
| 0.080 | 0.0330 |
| 0.120 | 0.0425 |
| 0.150 | 0.0505 |
| 0.177 | 0.0575 |
| 0.211 | 0.0675 |
| 0.260 | 0.0822 |
| 0.340 | 0.1075 |
| 1.500 | 0.4745 |

**MACH 0.85**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0175 |
| 0.020 | 0.0209 |
| 0.040 | 0.0248 |
| 0.096 | 0.0371 |
| 0.150 | 0.0505 |
| 0.177 | 0.0575 |
| 0.211 | 0.0675 |
| 0.260 | 0.0822 |
| 0.340 | 0.1075 |
| 1.500 | 0.4745 |

**MACH 0.9**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0180 |
| 0.020 | 0.0215 |
| 0.040 | 0.0253 |
| 0.096 | 0.0377 |
| 0.150 | 0.0510 |
| 0.177 | 0.0580 |
| 0.211 | 0.0680 |
| 0.260 | 0.0827 |
| 0.340 | 0.1080 |
| 1.500 | 0.4750 |

**MACH 0.925**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0200 |
| 0.020 | 0.0235 |
| 0.040 | 0.0274 |
| 0.096 | 0.0398 |
| 0.150 | 0.0530 |
| 0.177 | 0.0600 |
| 0.211 | 0.0700 |
| 0.260 | 0.0847 |
| 0.340 | 0.1100 |
| 1.500 | 0.4770 |

**MACH 0.95**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0245 |
| 0.020 | 0.0281 |
| 0.040 | 0.0319 |
| 0.096 | 0.0444 |
| 0.150 | 0.0575 |
| 0.177 | 0.0645 |
| 0.211 | 0.0745 |
| 0.260 | 0.0892 |
| 0.340 | 0.1145 |
| 1.500 | 0.4815 |

**MACH 1.010**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0410 |
| 0.020 | 0.0446 |
| 0.040 | 0.0485 |
| 0.073 | 0.0558 |
| 0.160 | 0.0767 |
| 0.211 | 0.0910 |
| 0.260 | 0.1057 |
| 0.340 | 0.1310 |
| 1.500 | 0.4980 |

**MACH 1.035**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0437 |
| 0.020 | 0.0474 |
| 0.040 | 0.0513 |
| 0.073 | 0.0586 |
| 0.160 | 0.0797 |
| 0.211 | 0.0937 |
| 0.260 | 0.1084 |
| 0.340 | 0.1337 |
| 1.500 | 0.5007 |

**MACH 1.050**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0455 |
| 0.020 | 0.0493 |
| 0.040 | 0.0527 |
| 0.073 | 0.0599 |
| 0.160 | 0.0811 |
| 0.211 | 0.0950 |
| 0.260 | 0.1097 |
| 0.340 | 0.1350 |
| 1.500 | 0.5020 |

$C_L$ = LIFT COEFFICIENT
$C_D$ = DRAG COEFFICIENT

TABLE 3 - F-8 TOTAL DRAG COEFFICIENT (C)

**MACH 1.075**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0455 |
| 0.020 | 0.0493 |
| 0.040 | 0.0533 |
| 0.073 | 0.0605 |
| 0.160 | 0.0819 |
| 0.211 | 0.0955 |
| 0.2[illegible] | 0.1102 |
| 0.340 | 0.1355 |
| 1.500 | 0.5025 |

**MACH 1.2**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0443 |
| 0.040 | 0.0528 |
| 0.100 | 0.0673 |
| 0.160 | 0.0828 |
| 0.220 | 0.0988 |
| 0.240 | 0.1048 |
| 0.305 | 0.1228 |
| 0.340 | 0.1348 |
| 0.350 | 0.1378 |
| 1.500 | 0.5013 |

**MACH 1.3**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0434 |
| 0.020 | 0.0482 |
| 0.040 | 0.0531 |
| 0.130 | 0.0774 |
| 0.240 | 0.1081 |
| 0.340 | 0.1374 |
| 0.512 | 0.1874 |
| 1.500 | 0.5004 |

**MACH 1.4**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0424 |
| 0.020 | 0.0476 |
| 0.040 | 0.0531 |
| 0.100 | 0.0709 |
| 0.160 | 0.0891 |
| 0.240 | 0.1136 |
| 0.340 | 0.1449 |
| 1.200 | 0.4141 |

**MACH 1.5**

| $C_L^2$ | $C_D$ |
|---|---|
| 0.000 | 0.0415 |
| 0.040 | 0.0539 |
| 0.120 | 0.0801 |
| 0.240 | 0.1205 |
| 0.340 | 0.1552 |
| 1.200 | 0.4535 |

$C_L$ = LIFT COEFFICIENT
$C_D$ = DRAG COEFFICIENT

TABLE 3 - F-8 TOTAL DRAG COEFFICIENT (C) (Cont'd)

| RADIANCY (WATTS/STR.) VS. ANGLE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\lambda_A$ TAIL (DEG. ±) \ $\lambda_E$ TAIL (DEG. ±) | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 60 | 70 | 80 | 90 |
| 0 | 230 | 226 | 220 | 211 | 200 | 191 | 180 | 167 | 150 | 141 | 130 | 100 | 60 | 20 | 10 |
| 5 | 226 | 223 | 218 | 210 | 199 | 190 | 178.5 | 166 | 150 | 140 | 128 | 99 | 60 | 20 | 10 |
| 10 | 220 | 218 | 213 | 205 | 197 | 186 | 176 | 164 | 150 | 138 | 125 | 98 | 58 | 20 | 10 |
| 15 | 211 | 210 | 205 | 199 | 191 | 181.5 | 172 | 166 | 148 | 135 | 123 | 95 | 56 | 19.5 | 10 |
| 20 | 200 | 199 | 197 | 191 | 183 | 177 | 166 | 155 | 143 | 132 | 120 | 92 | 53 | 19 | 10 |
| 25 | 191 | 190 | 186 | 181.5 | 177 | 167 | 159 | 148 | 138 | 126 | 114 | 89 | 50 | 18.5 | 10 |
| 30 | 180 | 178.5 | 176 | 172 | 166 | 159 | 150 | 141 | 132 | 121 | 109 | 83 | 46 | 17 | 10 |
| 35 | 167 | 166 | 164 | 160 | 155 | 148 | 141 | 135 | 124 | 114 | 104 | 77 | 41 | 17.5 | 10 |
| 40 | 150 | 150 | 150 | 148 | 143 | 138 | 132 | 124 | 116 | 107 | 98 | 70 | 37 | 16 | 10 |
| 45 | 141 | 140 | 138 | 135 | 132 | 126 | 121 | 114 | 107 | 99 | 79 | 62 | 33 | 15 | 10 |
| 50 | 130 | 128 | 125 | 123 | 120 | 114 | 109 | 104 | 98 | 79 | 78 | 55 | 28 | 14 | 10 |
| 60 | 100 | 99 | 98 | 95 | 92 | 89 | 83 | 77 | 70 | 62 | 55 | 35 | 20 | 12.5 | 10 |
| 70 | 60 | 60 | 58 | 56 | 53 | 50 | 46 | 41 | 37 | 33 | 28 | 20 | 16 | 11 | 10 |
| 80 | 20 | 20 | 20 | 19.5 | 19 | 18.5 | 17 | 17.5 | 16 | 15 | 14 | 12.5 | 11 | 10.5 | 10 |
| 90 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

TABLE 4 - F-8 INFRARED RADIANCY (1.8-2.7 MICRONS)(S)

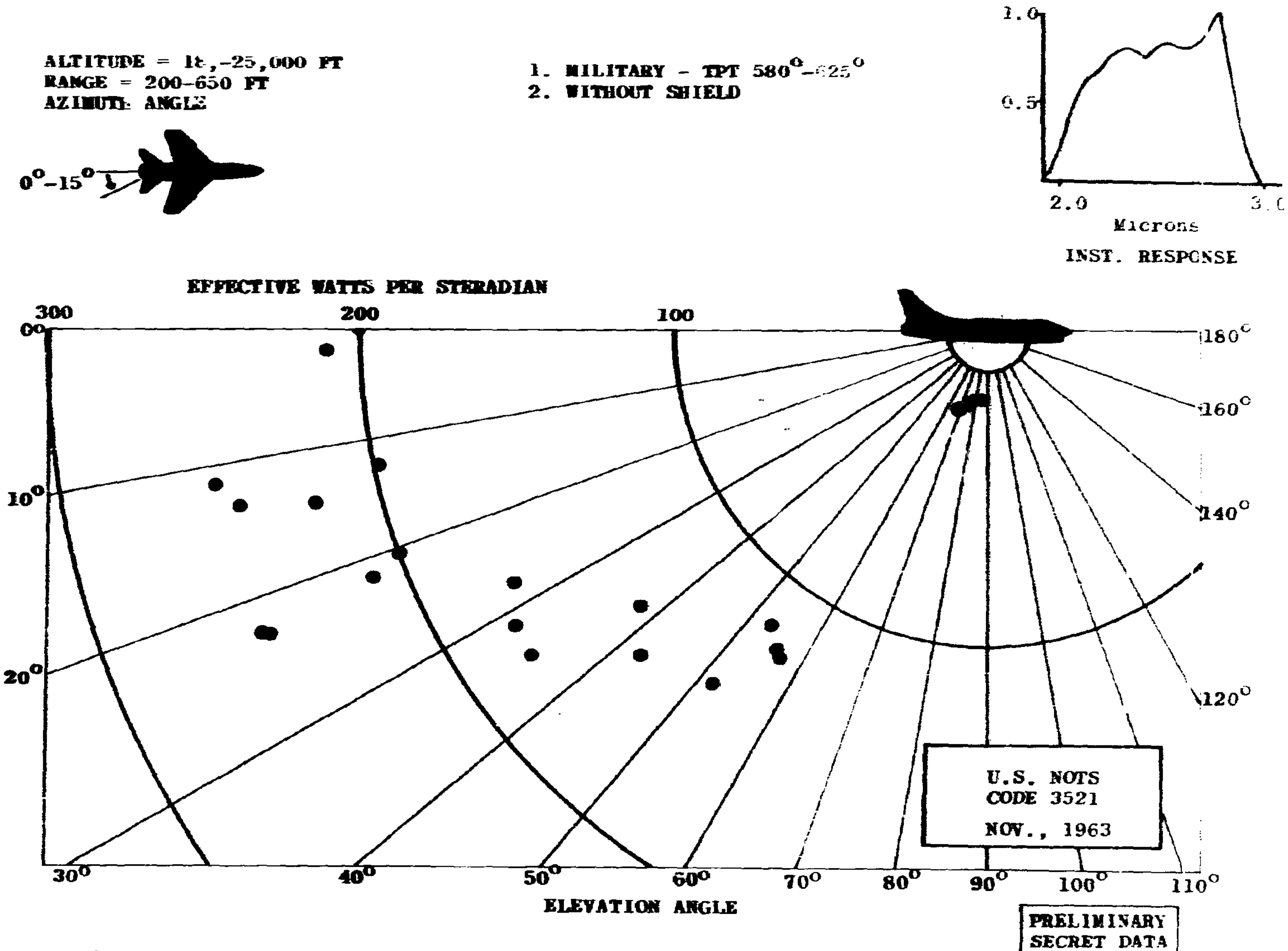
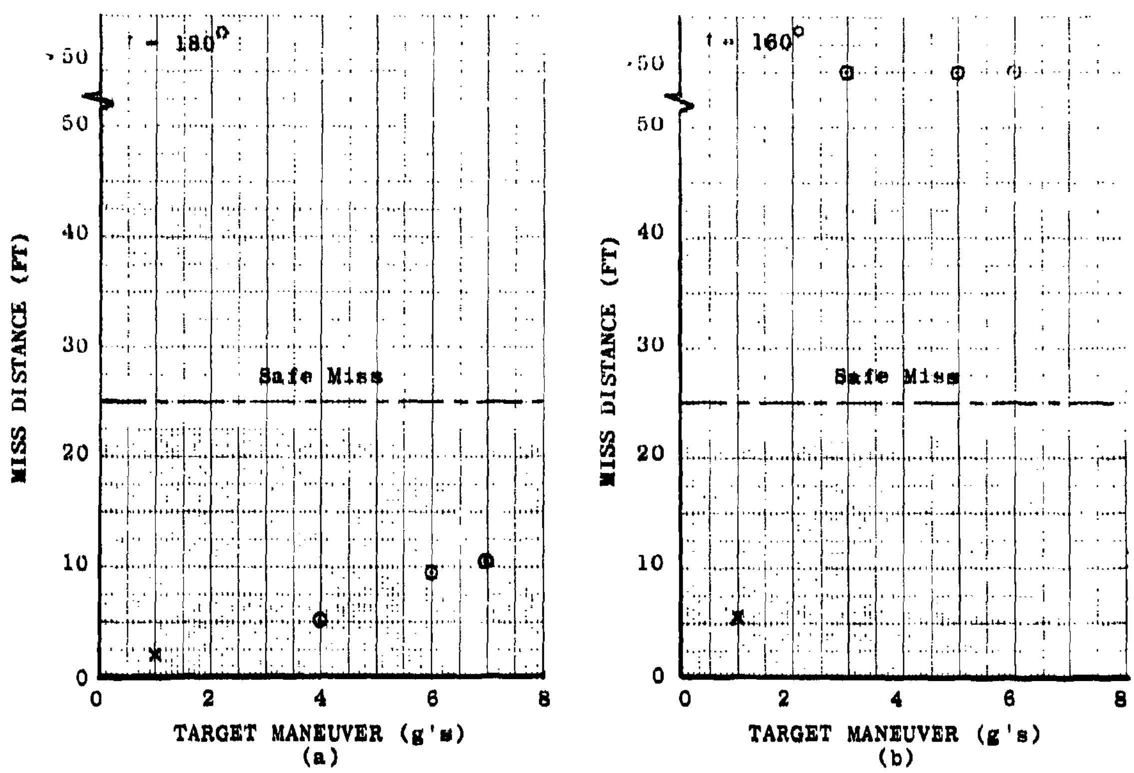



FIG. 1 - F-8 RADIANCY DATA (S)

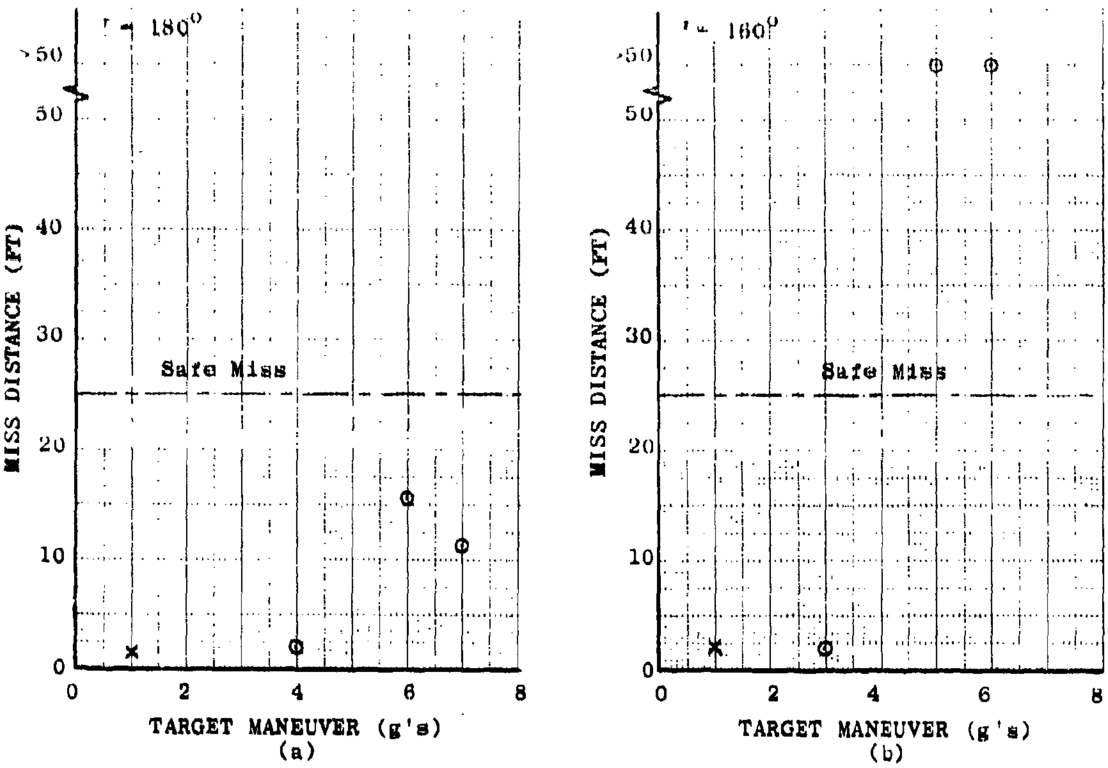



Target Altitude = 5000 ft
Target Speed = M 0.7
Launch Altitude = 5000 ft
Launch Speed = M 0.9
Launch Range = 3000 ft

○ Constant Turn Maneuver

× No Maneuver

FIG. 2 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

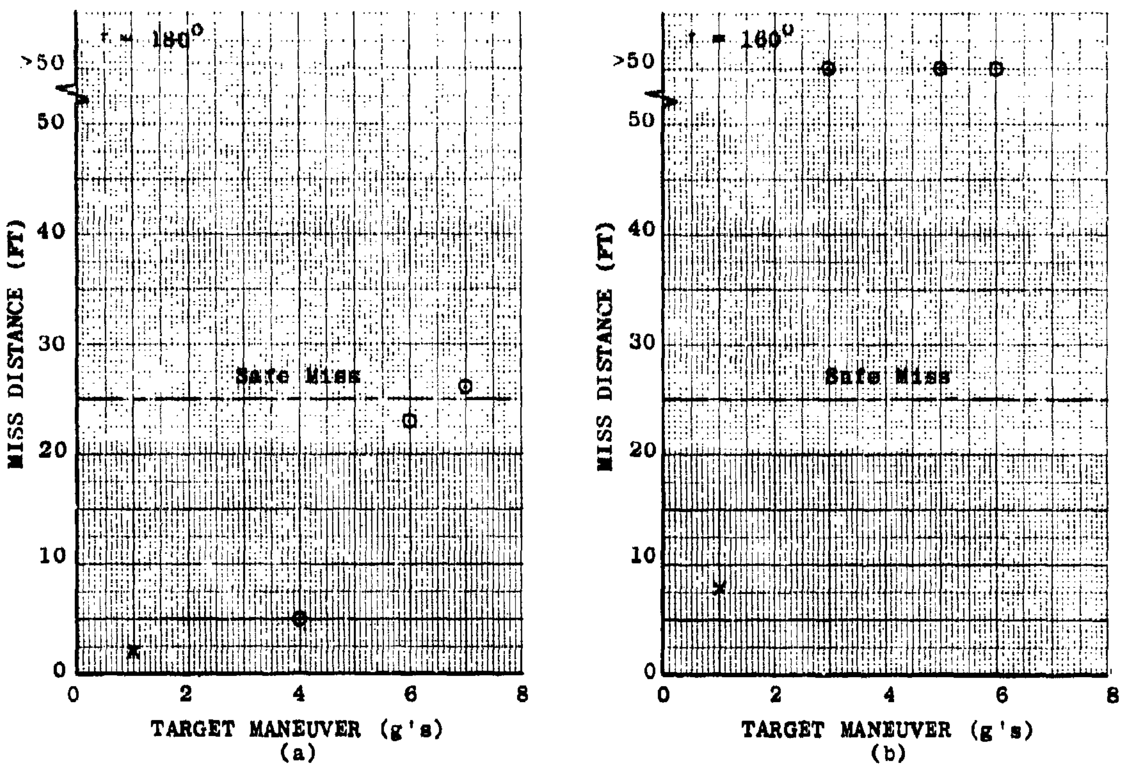



Target Altitude = 5000 ft
Target Speed = M 0.7
Launch Altitude = 5000 ft
Launch Speed = M 0.9
Launch Range = 5000 ft

o Constant Turn Maneuver

× No Maneuver

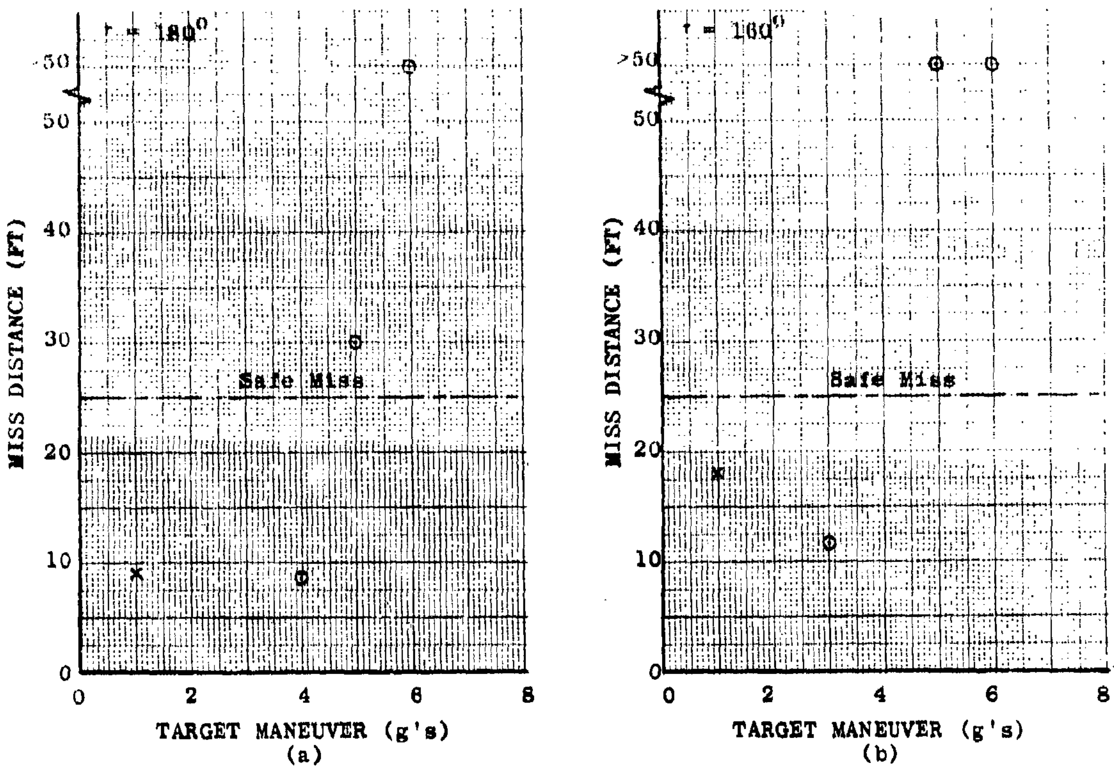
FIG. 3 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)




Target Altitude = 5000 ft
Target Speed = M 0.9
Launch Altitude = 5000 ft
Launch Speed = M 0.9
Launch Range = 3000 ft

o Constant Turn Maneuver
× No Maneuver

FIG. 4 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

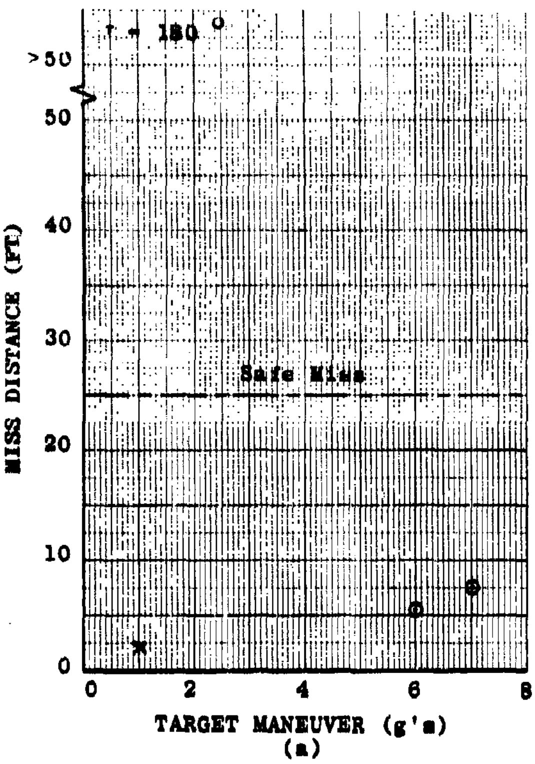


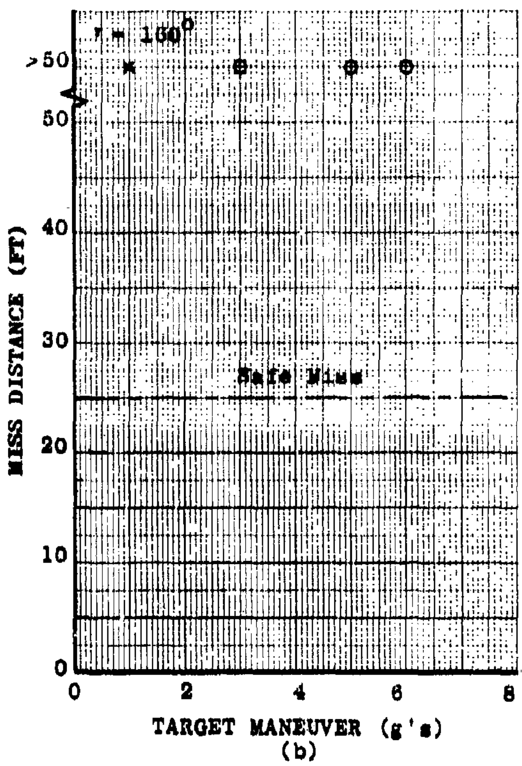

Target Altitude = 5000 ft
Target Speed = M 0.9
Launch Altitude = 5000 ft
Launch Speed = M 0.9
Launch Range = 5000 ft

o Constant Turn Maneuver

x No Maneuver

FIG. 5 - APOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)



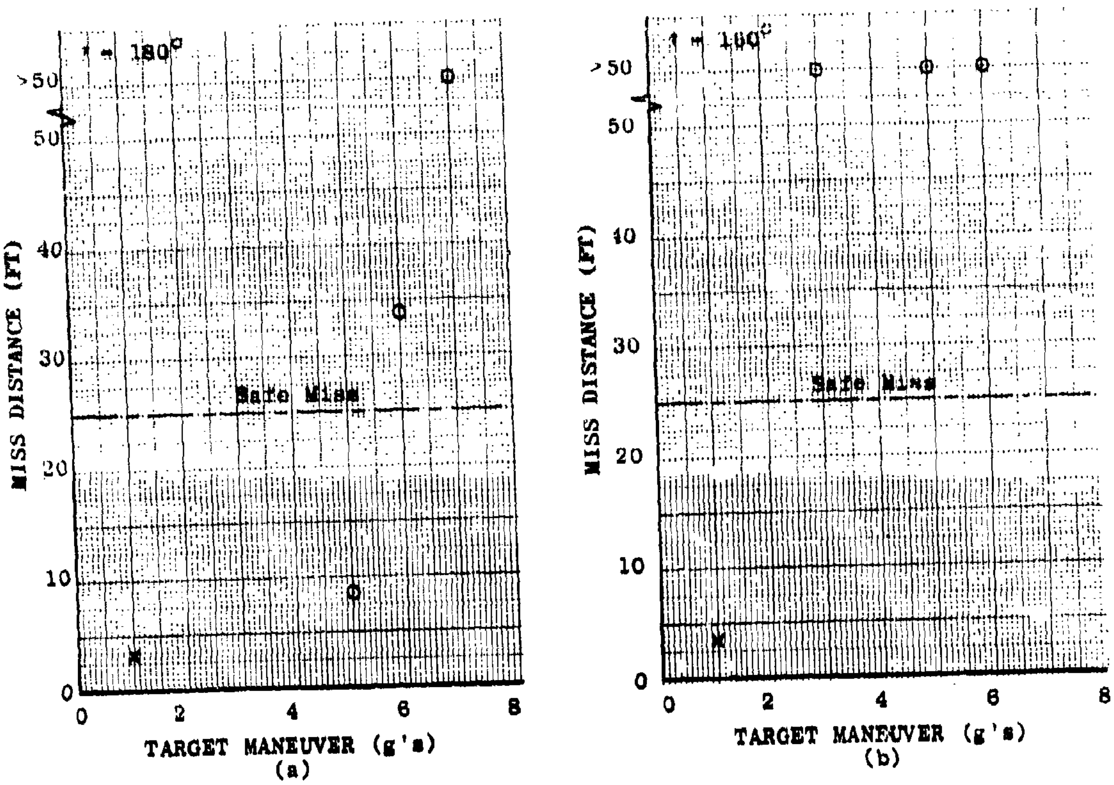




Target Altitude = 5000 ft
Target Speed = M 0.9
Launch Altitude = 5000 ft
Launch Speed = M 1.2
Launch Range = 3000 ft

o Constant Turn Maneuver

× No Maneuver

FIG. 6 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

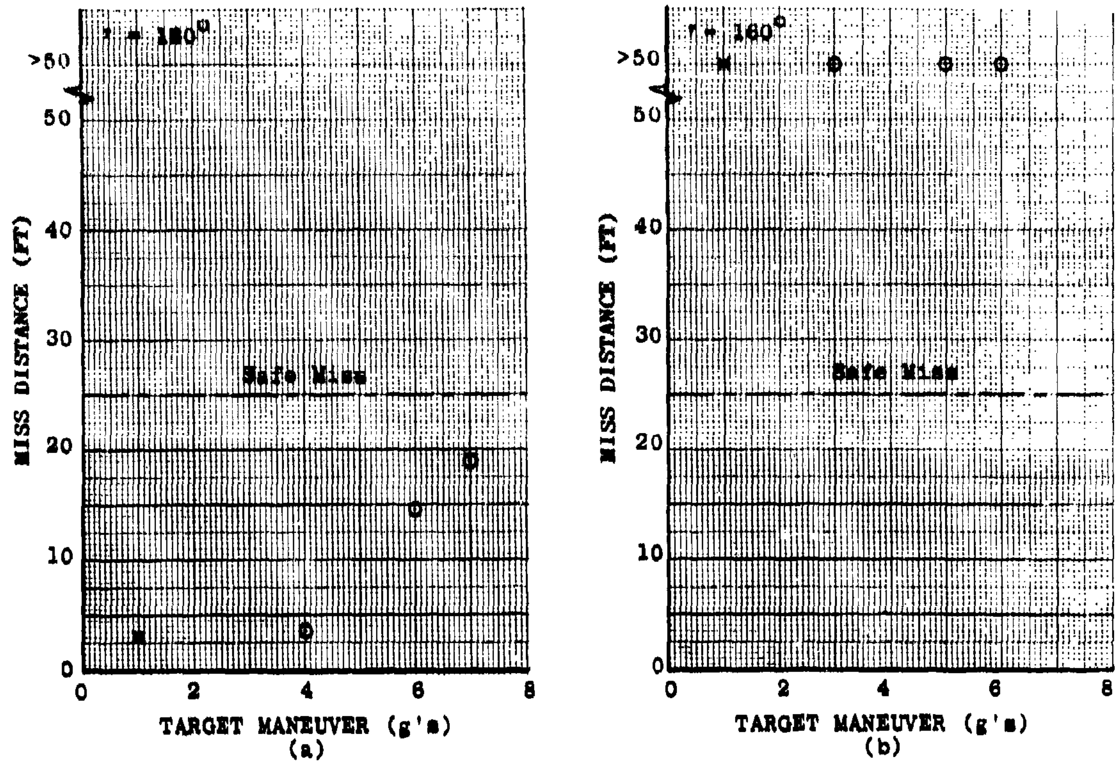



Target Altitude = 5000 ft
Target Speed = M 0.9
Launch Altitude = 5000 ft
Launch Speed = M 1.2
Launch Range = 5000 ft

○ Constant Turn Maneuver

× No Maneuver

FIG. 7 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

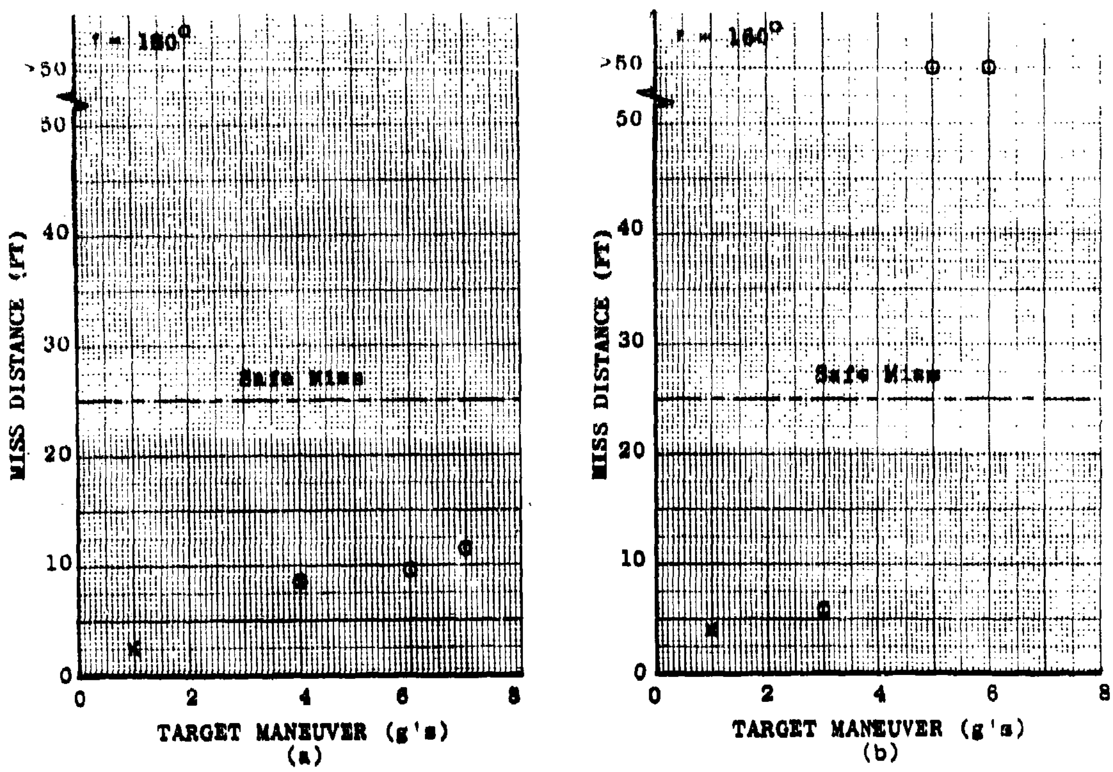



Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M3009 ft
Launch Range = 3000 ft

o Constant Turn Maneuver

x No Maneuver

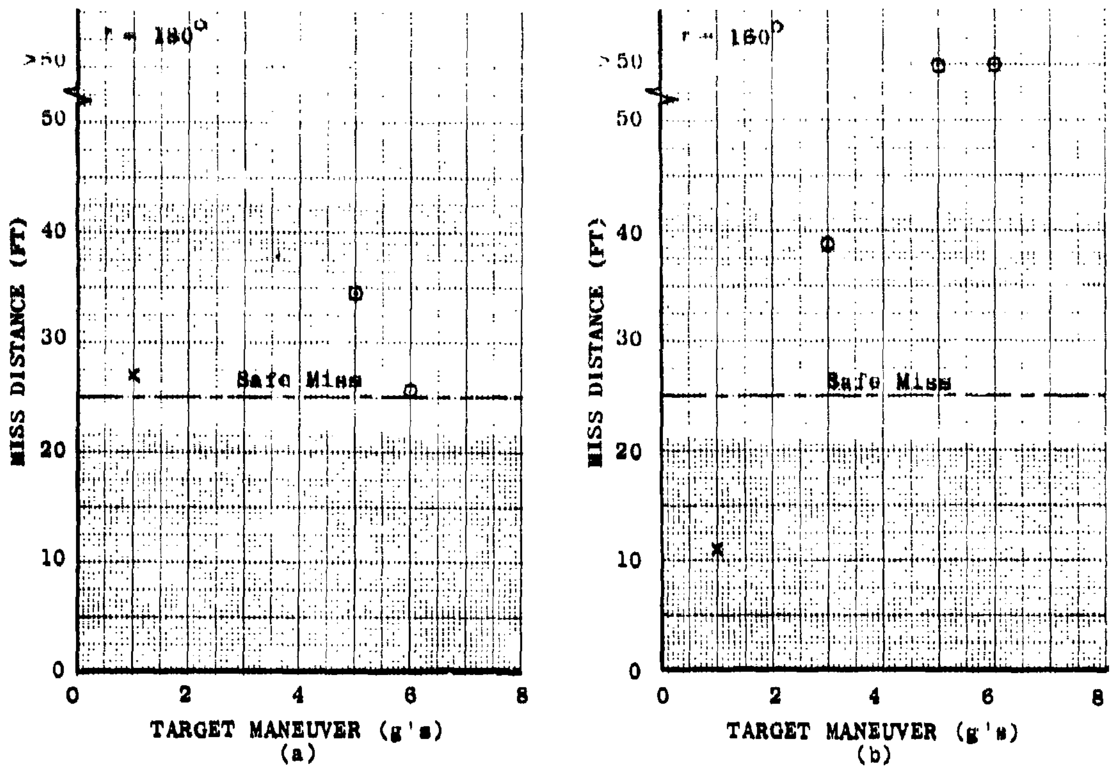
FIG. 8 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)




Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M 0.9
Launch Range = 5000 ft

o Constant Turn Maneuver
x No Maneuver

FIG. 9 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

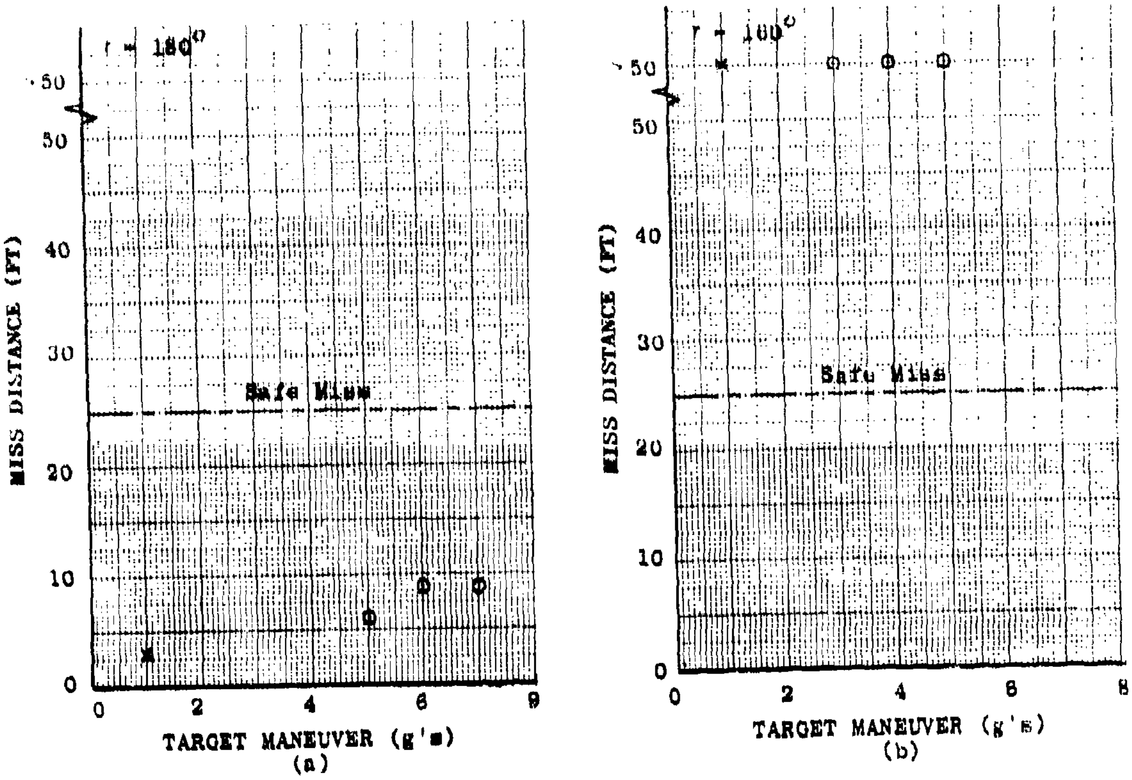



Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M 0.9
Launch Range = 7000 ft

o Constant Turn Maneuver

x No Maneuver

FIG. 10 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

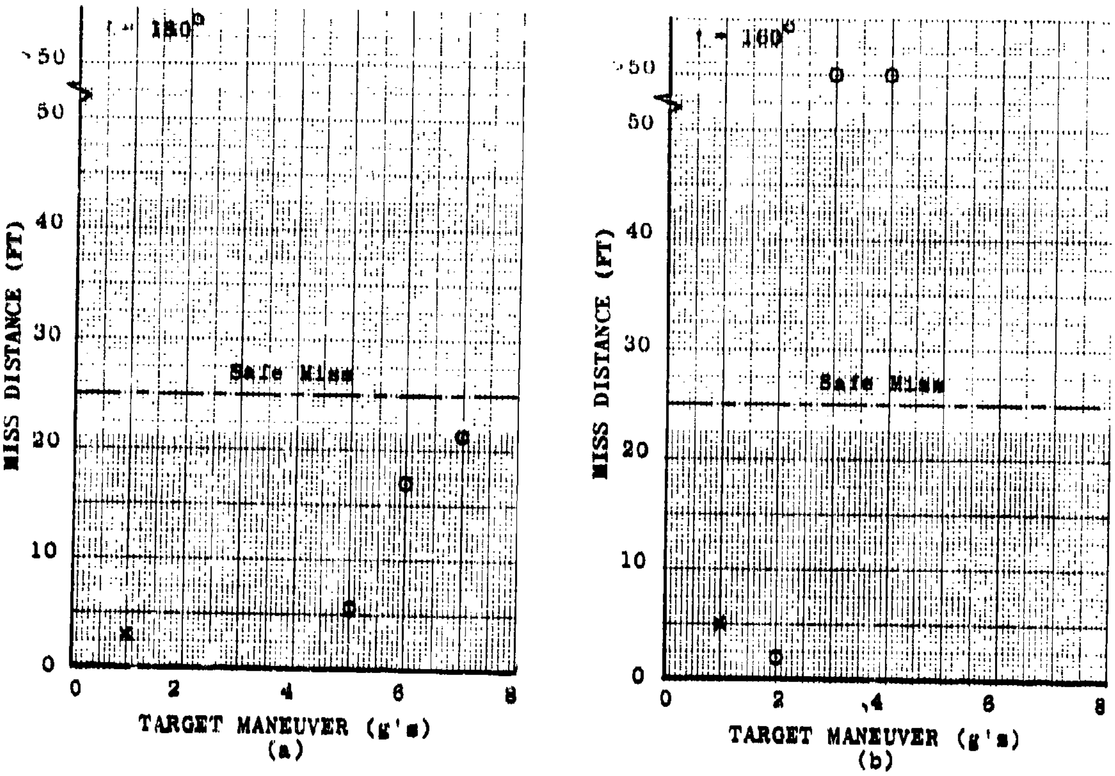



Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M 1.2
Launch Range = 3000 ft

o Constant Turn Maneuver

x No Maneuver

FIG. 11 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

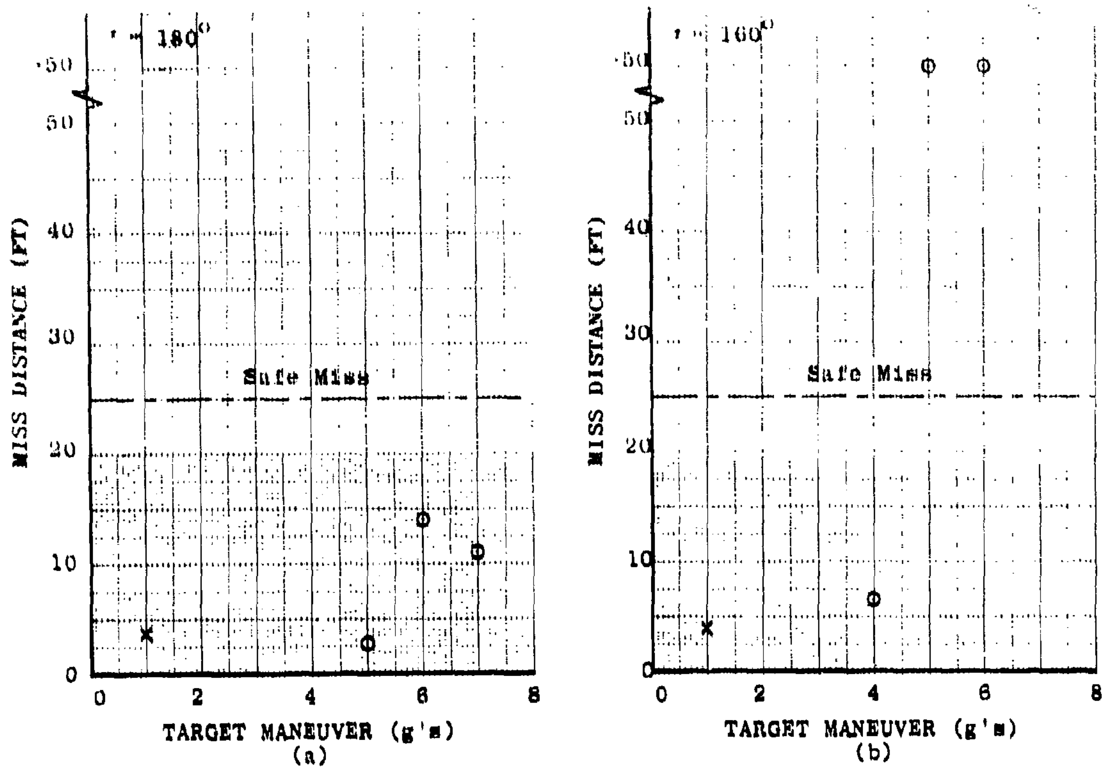



Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M 1.2
Launch Range = 5000 ft

o Constant Turn Maneuver

x No Maneuver

FIG. 12 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

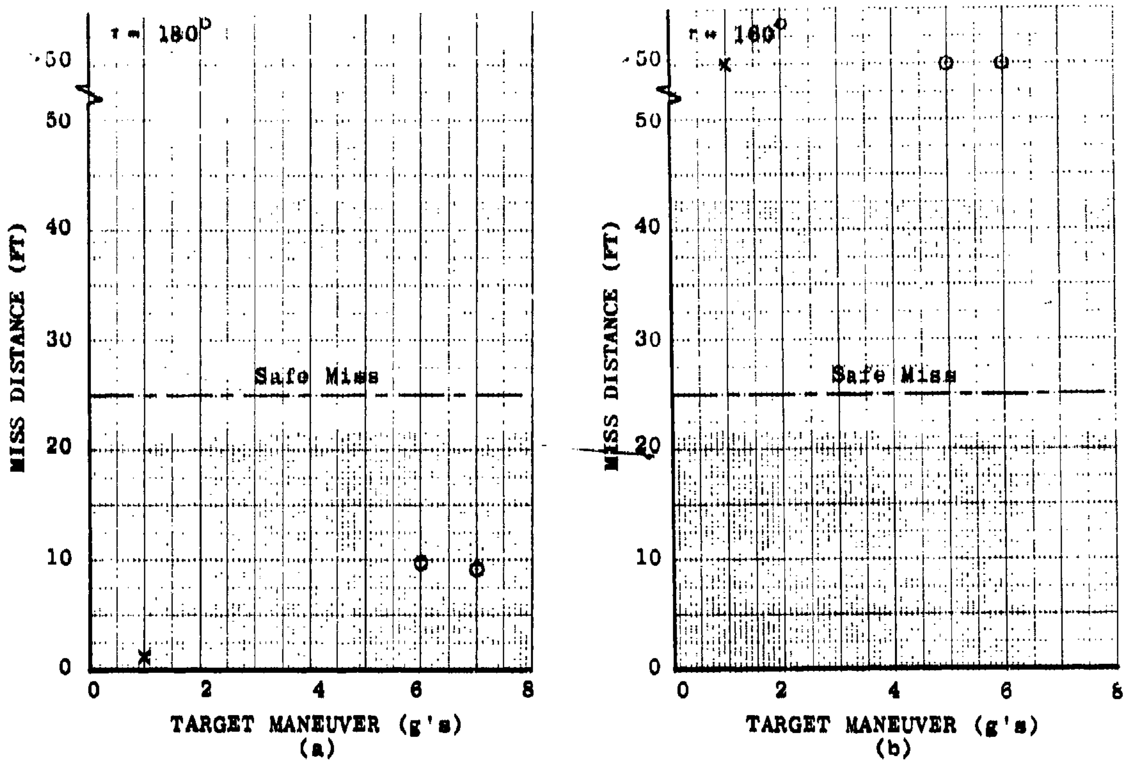



Target Altitude = 15000 ft
Target Speed = M 0.9
Launch Altitude = 15000 ft
Launch Speed = M 1.2
Launch Range = 7000 ft

○ Constant Turn Maneuver

× No Maneuver

FIG. 13 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

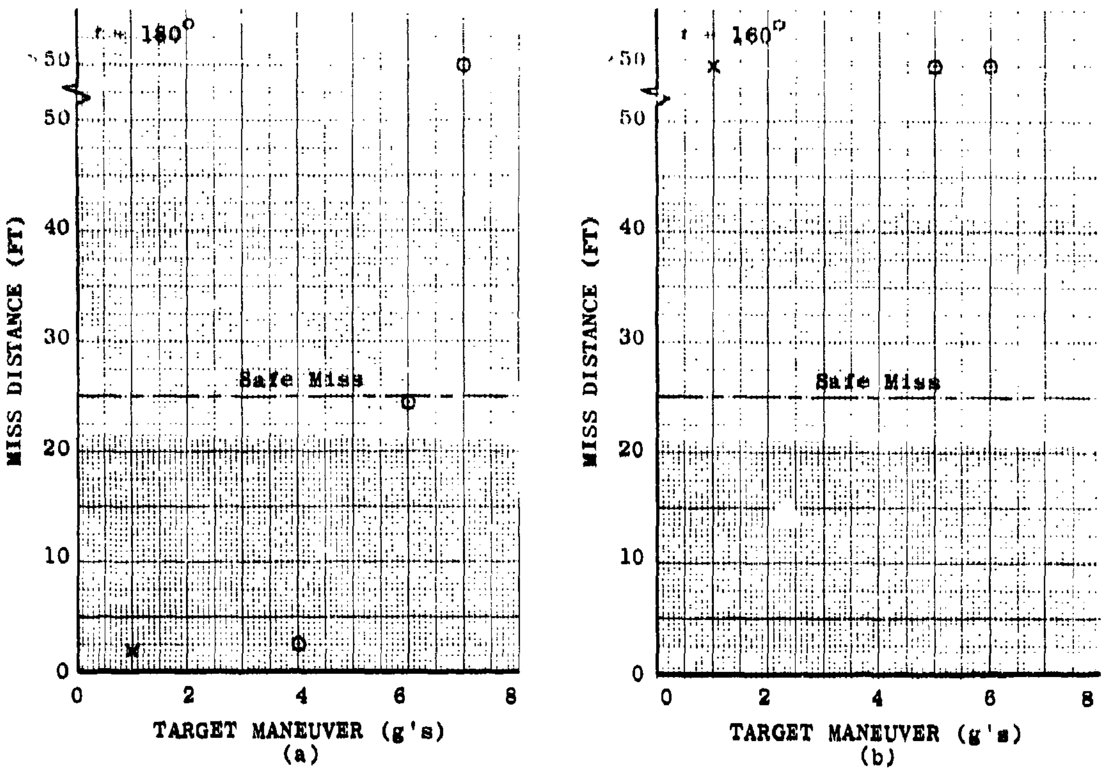



Target Altitude = 15000 ft
Target Speed = M 1.2
Launch Altitude = 15000 ft
Launch Speed = M 1.5
Launch Range = 3000 ft

o Constant Turn Maneuver

× No Maneuver

FIG. 14 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

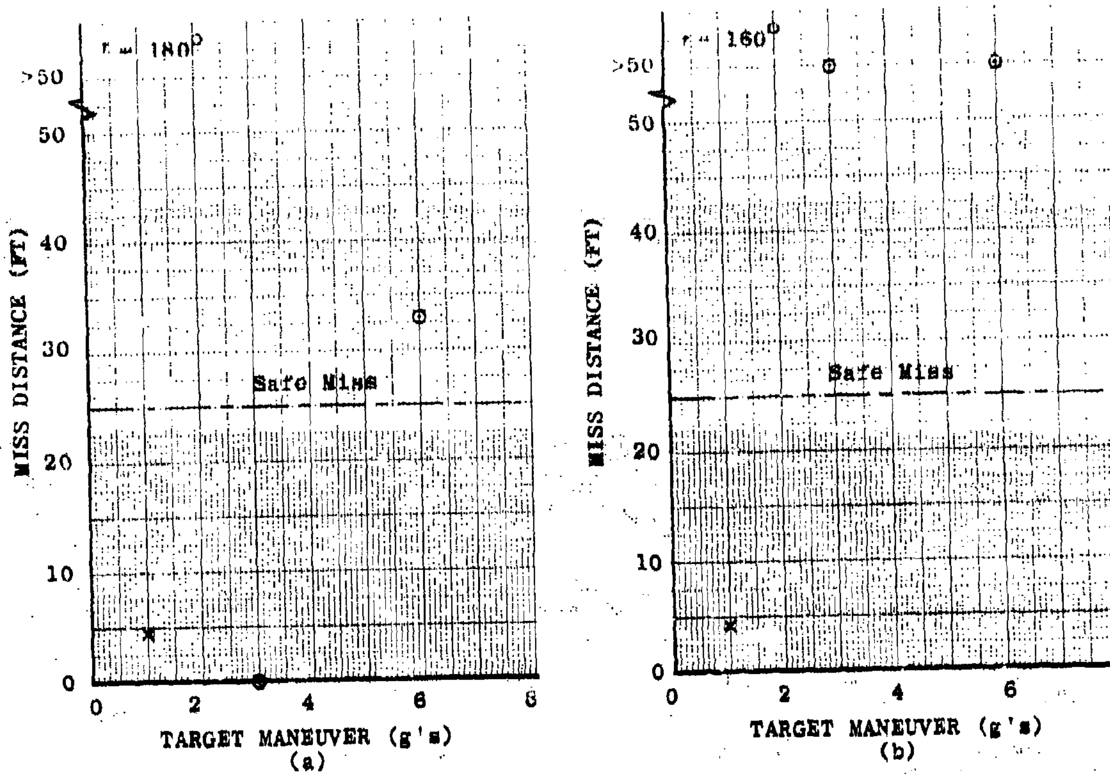



Target Altitude = 15000 ft
Target Speed = M 1.2
Launch Altitude = 15000 ft
Launch Speed = M 1.5
Launch Range = 5000 ft

o Constant Turn Maneuver

× No Maneuver

FIG. 15 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

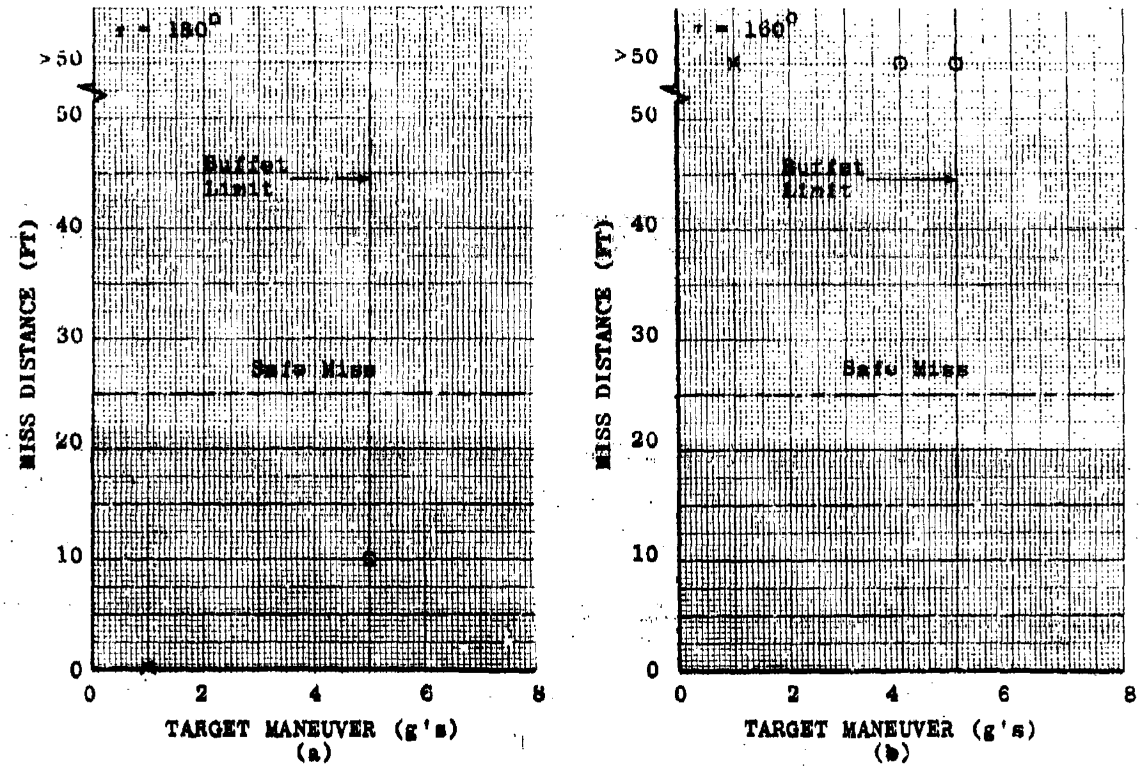



Target Altitude = 15000 ft
Target Speed = M 1.2
Launch Altitude = 15000 ft
Launch Speed = M 1.5
Launch Range = 6000 ft

○ Constant Turn Maneuver

× No Maneuver

FIG. 16 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

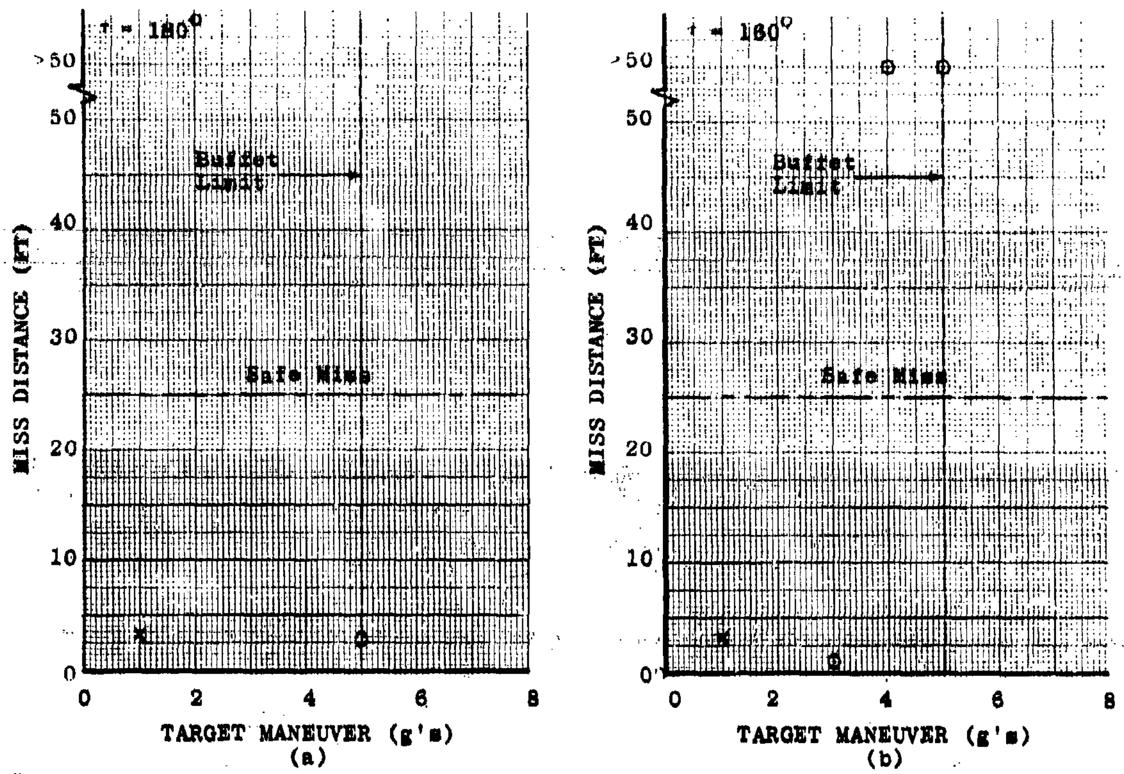



Target Altitude = 30000 ft
Target Speed = M 0.9
Launch Altitude = 30000 ft
Launch Speed = M 1.2
Launch Range = 4000 ft

o Constant Turn Maneuver

× No Maneuver

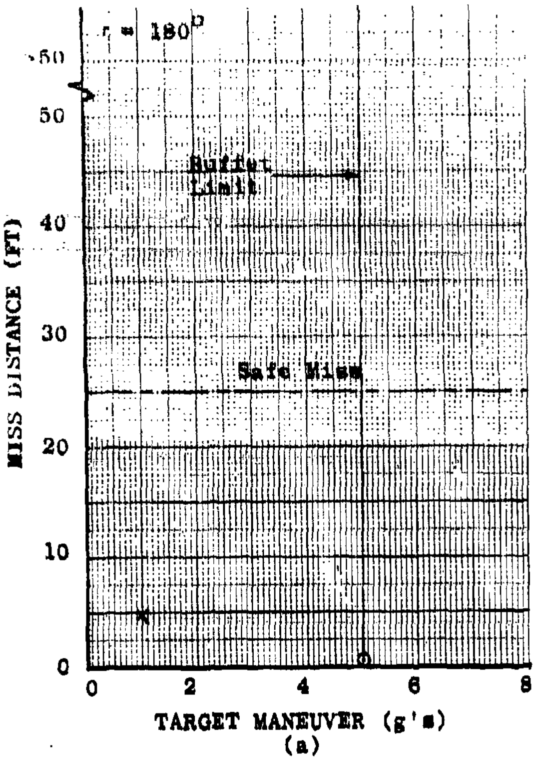
FIG. 17 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

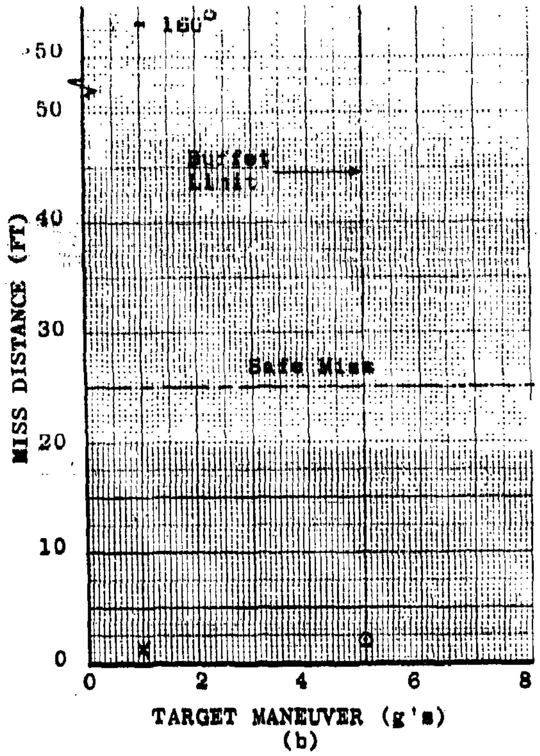



Target Altitude = 30000 ft
Target Speed = M 0.9
Launch Altitude = 30000 ft
Launch Speed = M 1.2
Launch Range = 8000 ft

o Constant Turn Maneuver
× No Maneuver

FIG. 18 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)




Target Altitude = 30000 ft
Target Speed = M 0.9
Launch Altitude = 30000 ft
Launch Speed = M 1.2
Launch Range = 12000 ft

o Constant Turn Maneuver

x No Maneuver

FIG. 19 - ATOLL MISS DISTANCE AS A FUNCTION OF F-8 LOAD FACTOR (S)

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13. ABSTRACT (Secret)

An analysis was made to determine the capability of the F-8 aircraft to evade the ATOLL missile by maneuver. Realistic computer simulations of both the ATOLL and the F-8 were combined with the IR characteristics of the F-8 and the atmosphere to provide the tool for analysis. The simulation results define maneuver requirements for the F-8 in the air combat maneuvering environment. It is concluded that maneuver alone is not always a sufficient countermeasure.

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| ATOLL<br>F-8 aircraft<br>Countermeasures<br>Aircraft maneuvers | | | | | | |

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